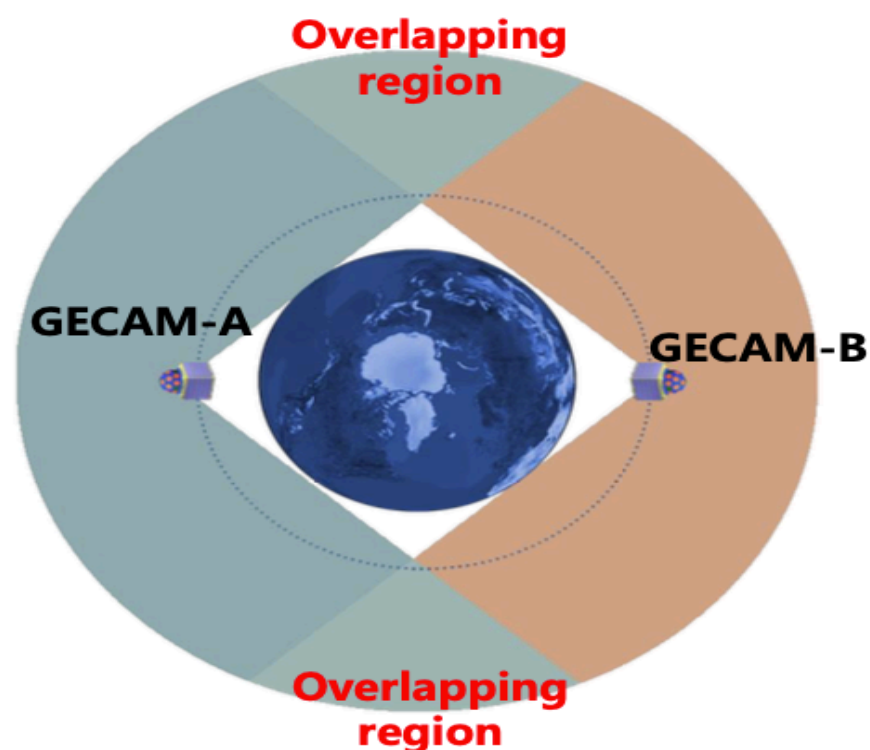


利用 SVOM/GWAC 系统搜索和确认GECAM触发的暂现源候选体

辛立平、韩旭辉、魏建彦

(国家天文台)

2020-11-01, 北京, GECAM研讨会



GECAM 为多波段暂现源探测与研究提供了良好机遇！

• 星上警报

- 触发时间、星上定位等
- 延迟: **1-3 minutes**

• 地面自动处理短报文警报

- 更准确的定位、能谱、T90等
- 延迟: **10-20 minutes**

• 地面自动处理数传数据警报

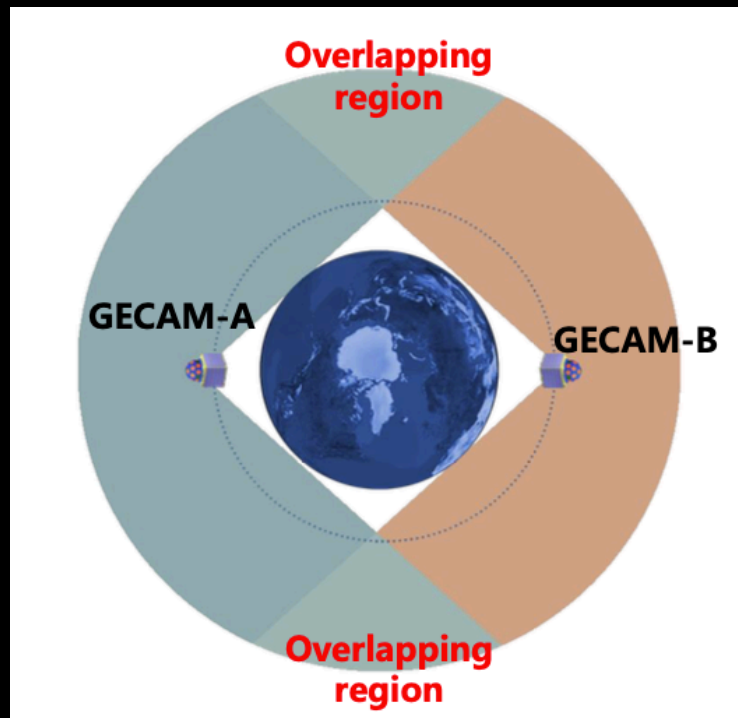
- 更准确的定位、能谱、T90等
- 延迟: **~hours**

• 最终警报

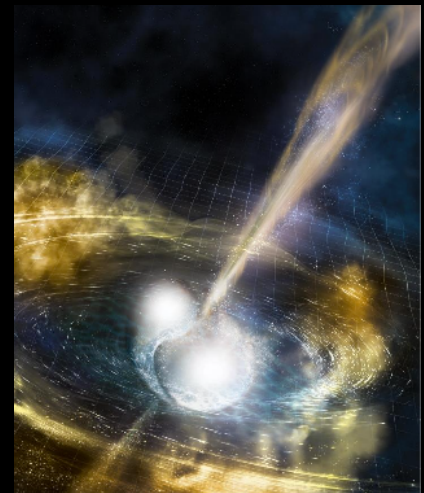
- 双星的最终分析结果
- 延迟: **~hours**

1. 视场：全天
2. **500GRB/年**
3. 定位~1度
4. 实时警报

天 (GECAM) 地 (GWAC) 联合观测



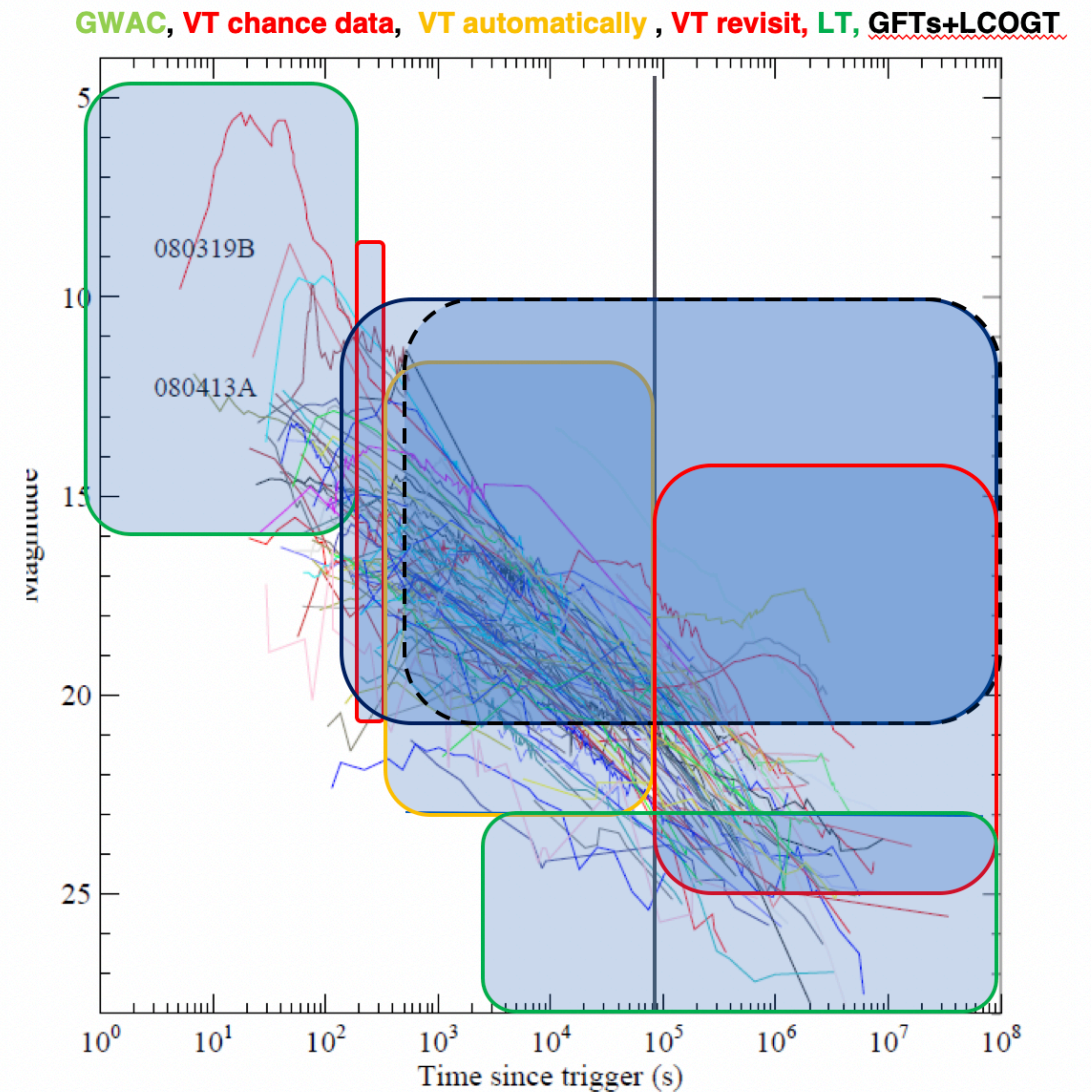
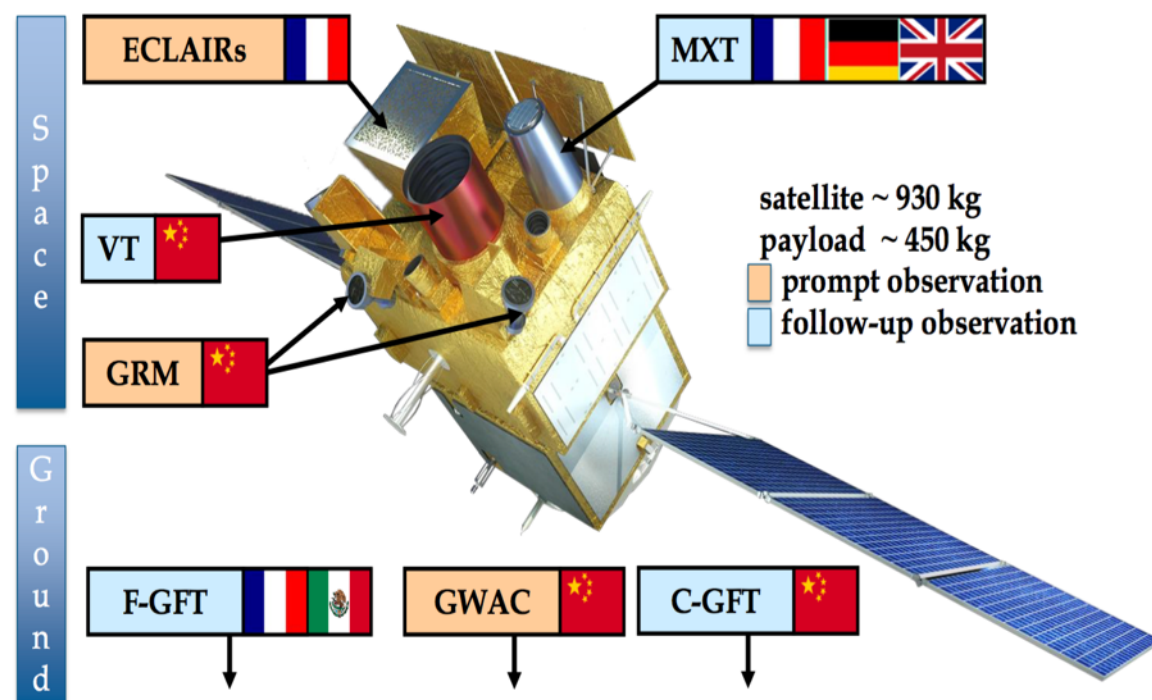
警报/信息
暂现源候选体



GWAC as a key facility of the future Chinese-French space mission SVOM

PI: Jianyan Wei & Cordier Bertrand

- 探测GRB的瞬时光学辐射
- 提供光变和能谱的关键数据

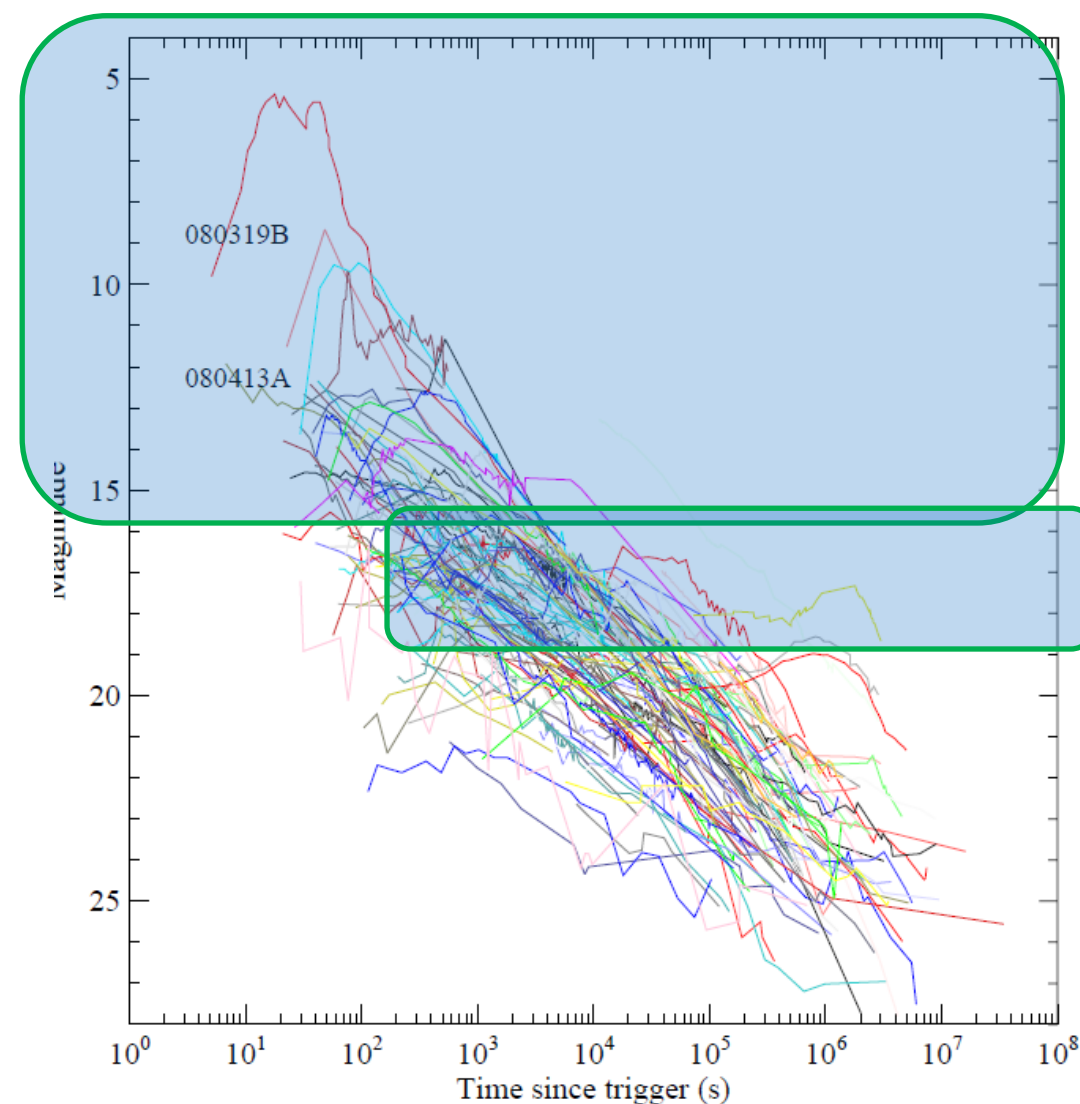
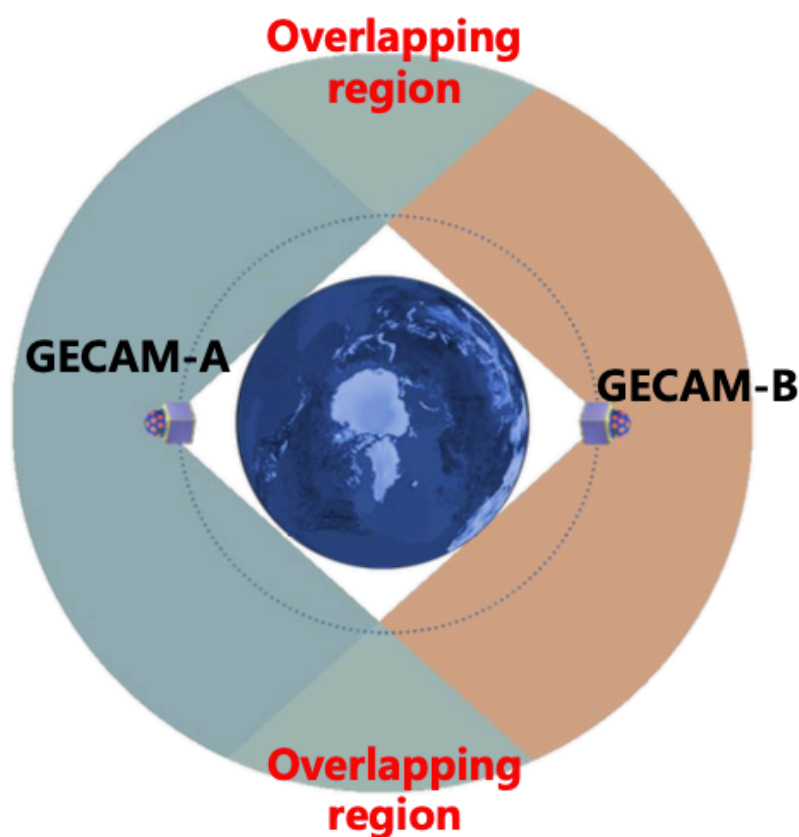


GWAC系统最终建设目标是：

视场：~5000平方度，时间分辨率15秒，单帧探测深度V16mag

(GWAC+F60+F30) + GECAM

- 探测GRB的瞬时光学辐射
- 提供光变和能谱的关键数据



GWAC系统最终建设目标是：

视场：~5000平方度，时间分辨率15秒，单帧探测深度V16mag

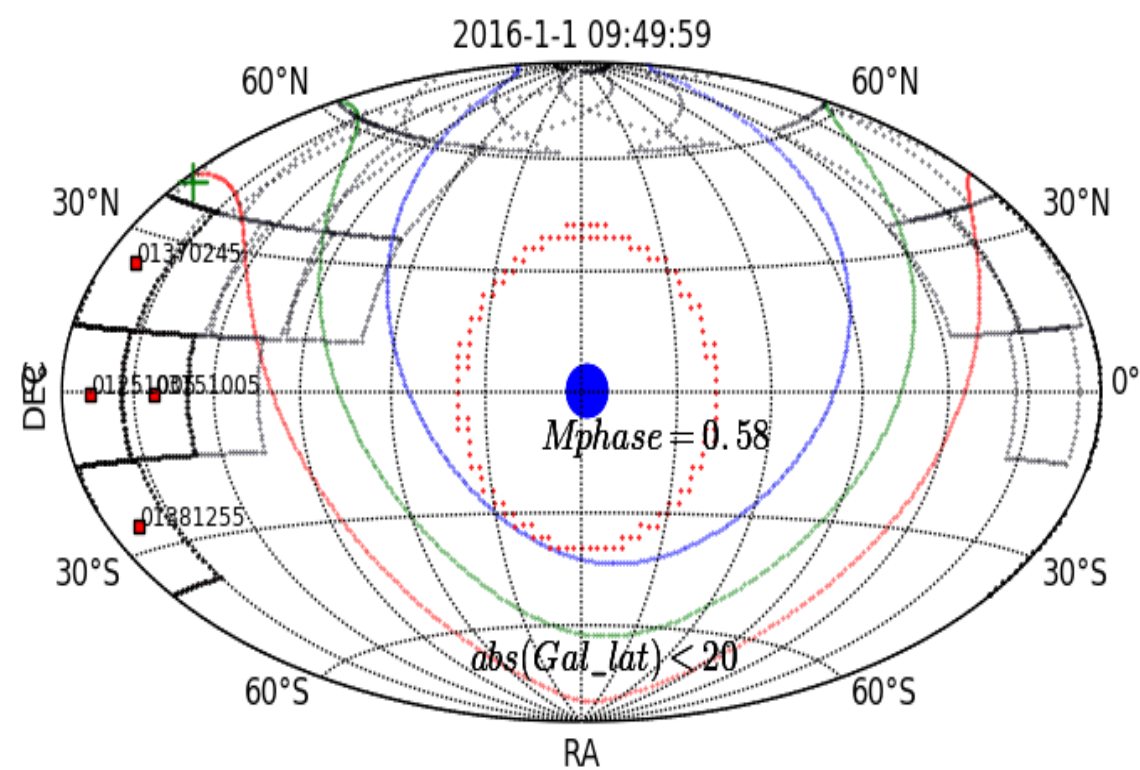
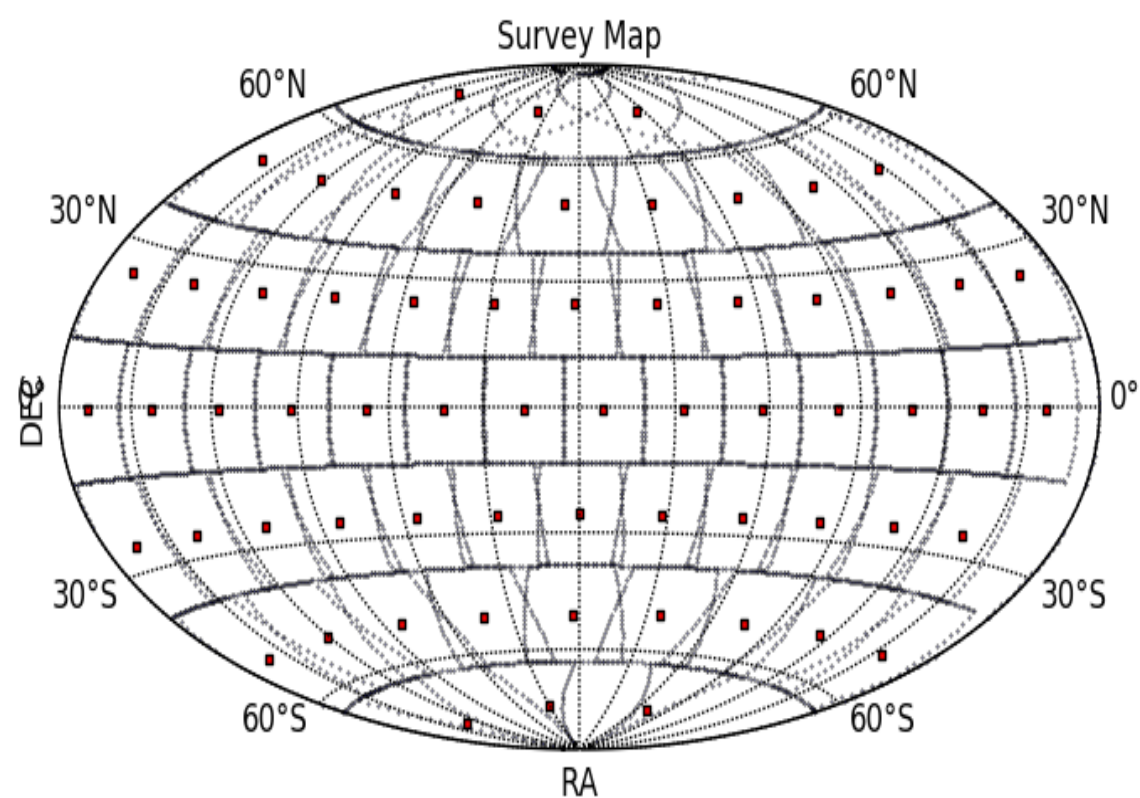
GWAC及其附属后随望远镜



Great contributions from NAOC, Guangxi Uni., Nanjing Uni., Huaibei normal Uni. etc

Telescope	Num for O3	Location	Aperture (cm)	FoV	Filter	m _{limt} [Single/Stack]	Obs. mode for ToO
GWAC	3 / 4	Xinglong	18	24°x24°	Clear	16/18	Tiling
F-60A/B	2	Xinglong	60	9.8'x9.8' / 19'x19' (2Kx2K)	Clear, BRI	18/19	Pointing
30cm	1	Xinglong	30	1.8°x1.8°	Clear, BRI	16.5/18	Tiling / Pointing

GWAC大视场观测：按天区逐一扫描 (巡天+ToO)



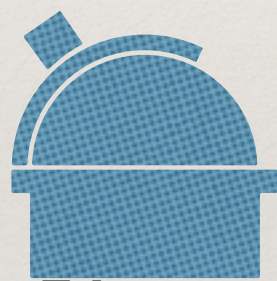
GWAC观测引力波/伽马暴警报和后随系统的建设



Open Public Access
(OPA) GW alerts



In the frame of SVOM:
1. recomposed GW alerts
2. optimized tiling lists
3. optimized galaxy lists



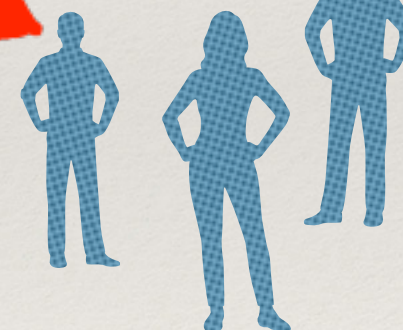
Telescopes

1. Scheduler
2. Observation
3. Data processing pipeline
4. Data storage
5. Observing interface
6. Obs. information & results



Chinese Multi-messenger

- Science Center (CMM)
1. Alert decoder
 2. Databases
 3. FTP server
 4. BA interface



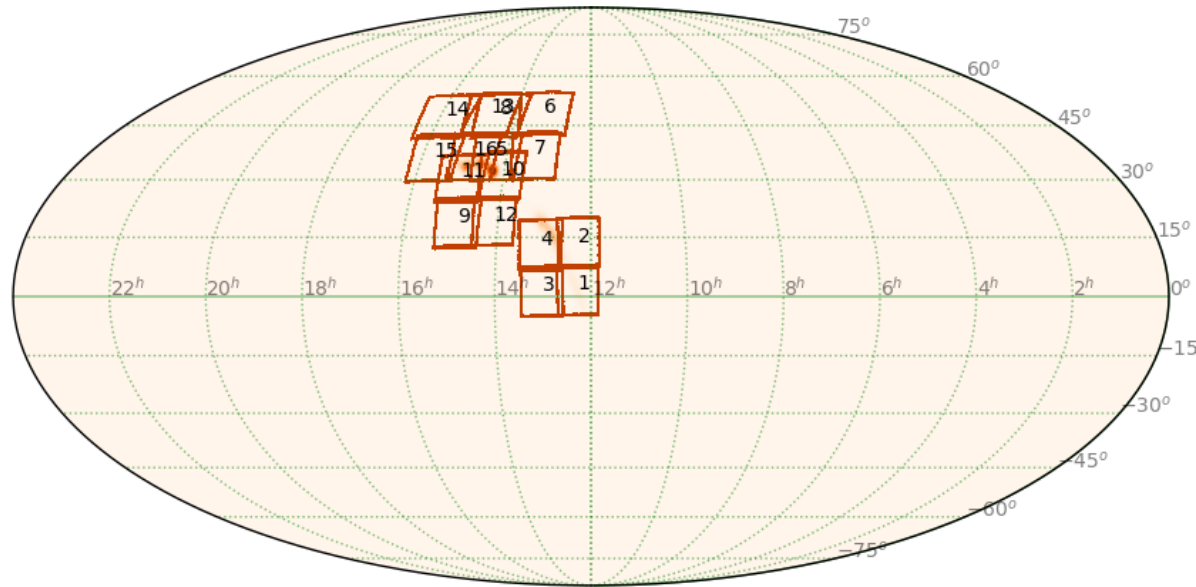
BA Team

1. EM counterpart identifying
2. Observing organization
3. Publication

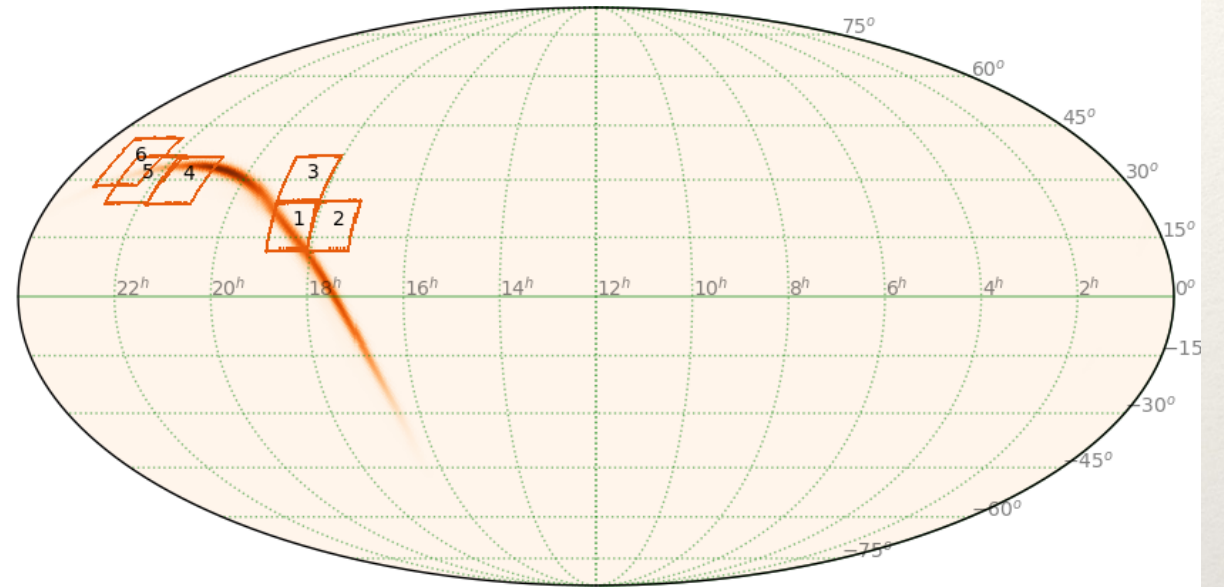
GWAC对GW后随事例

大天区覆盖=降低时间延迟=亮度衰减不明显=提高探测率

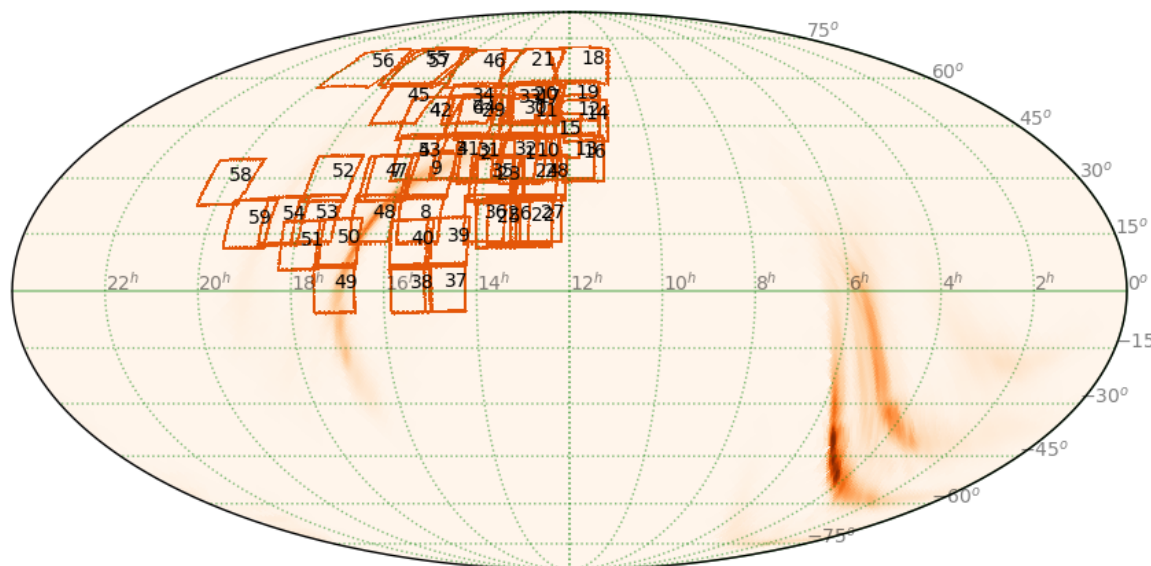
GWAC coverage for S190412m



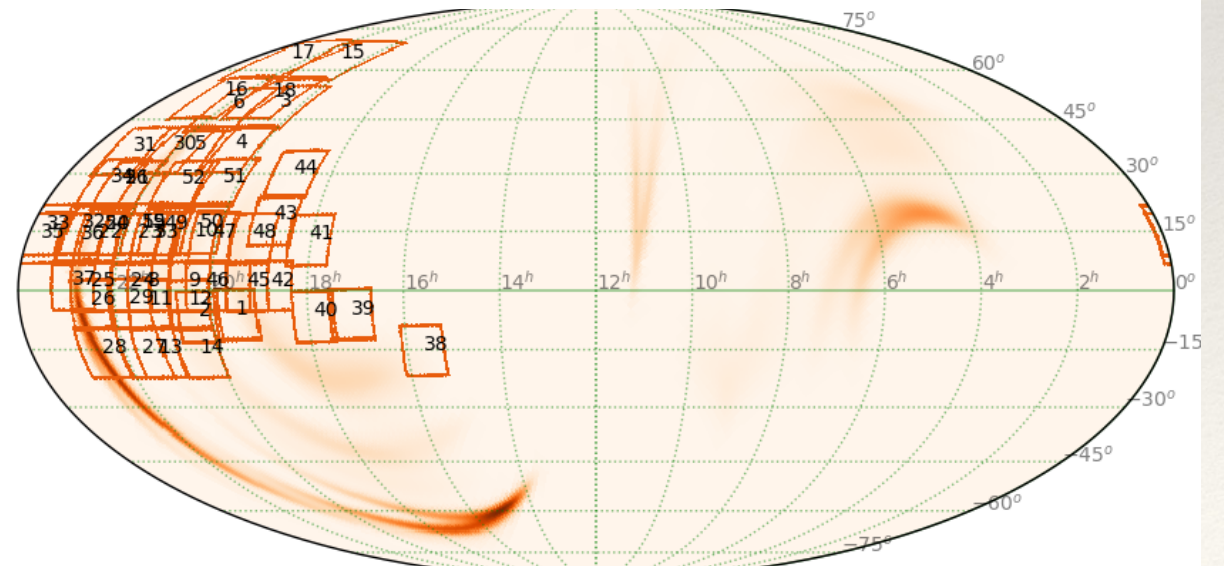
GWAC coverage for S190521r



GWAC coverage for S190425z



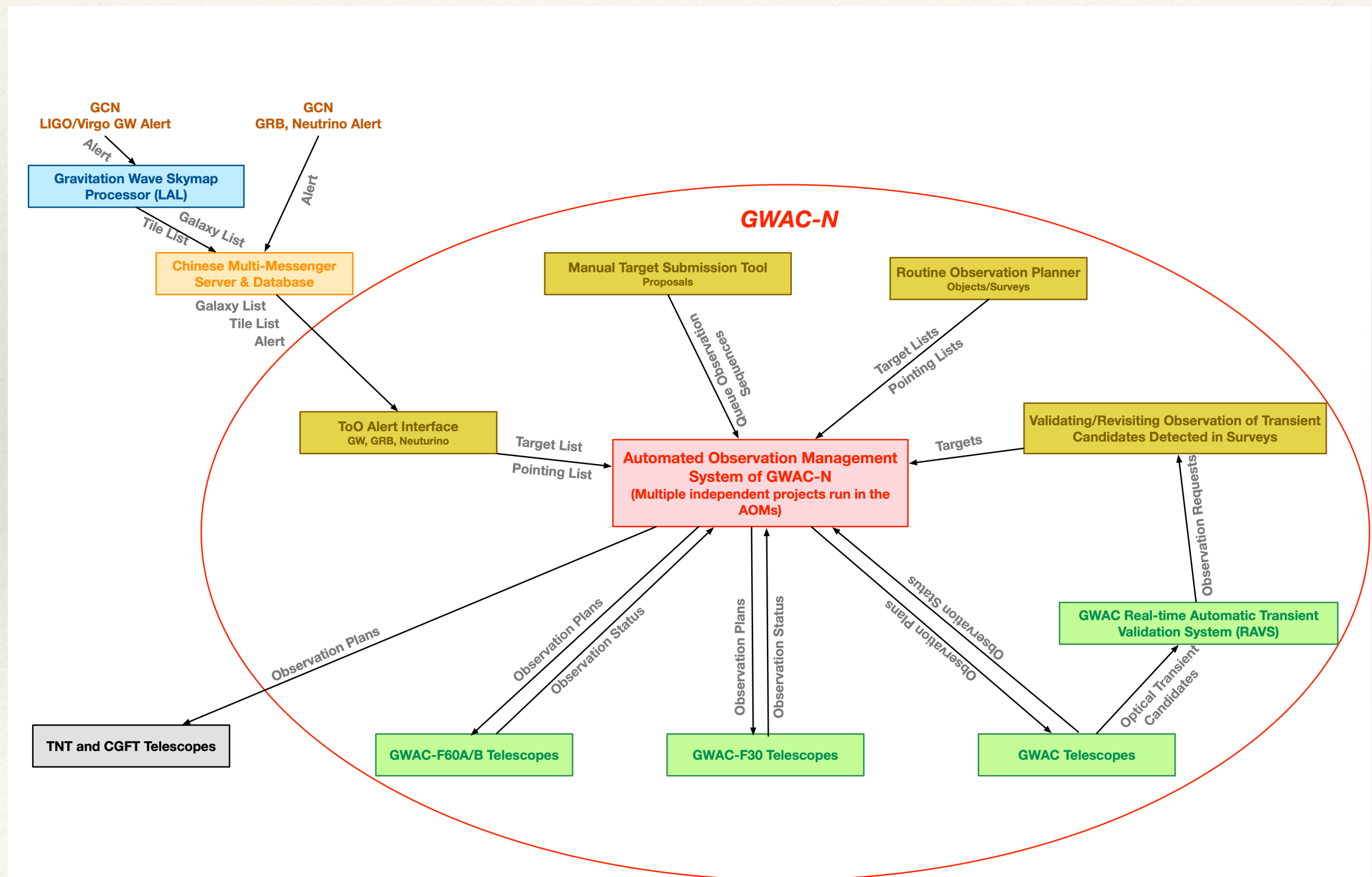
GWAC coverage for S190630ag



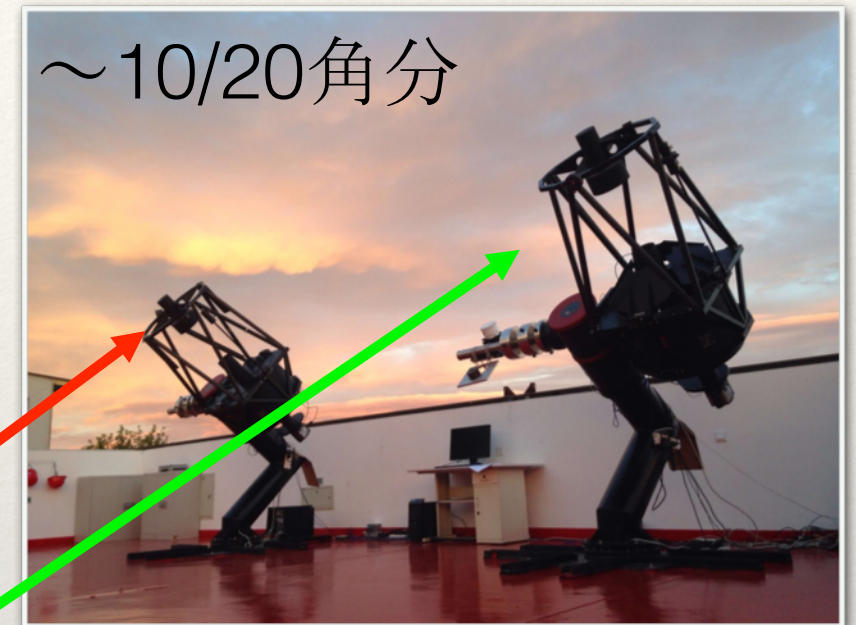
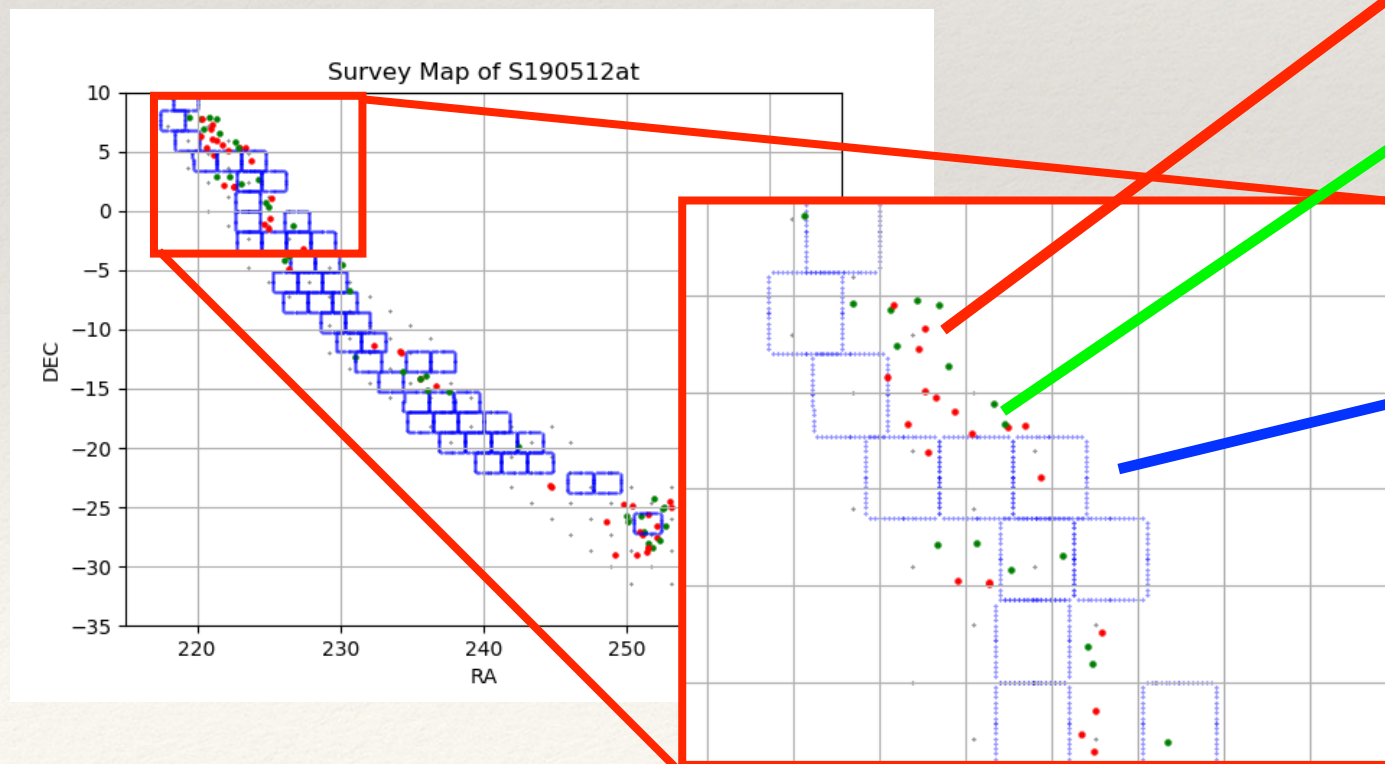
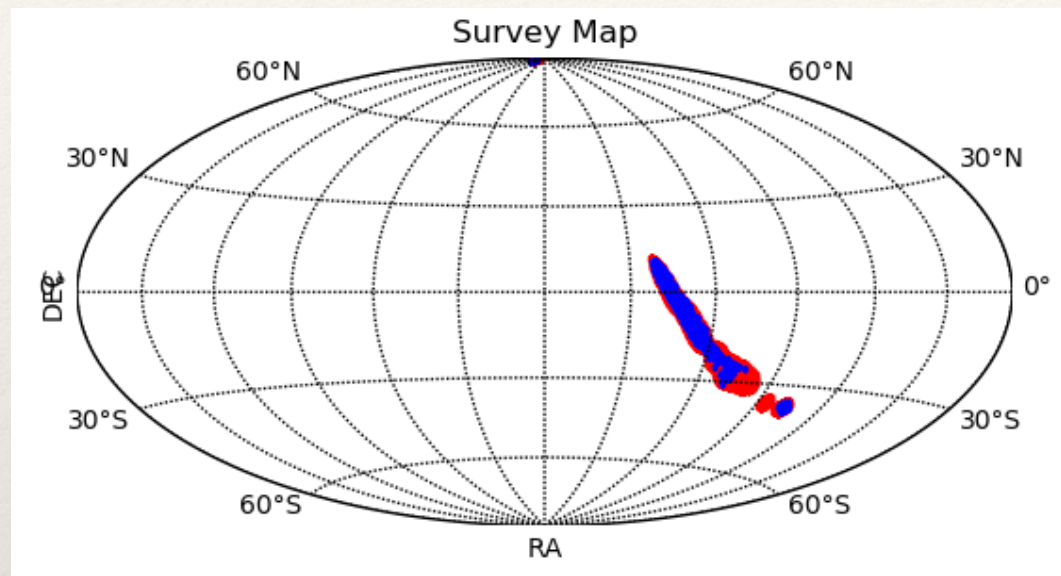
AOM : An Automatic Observation Management System of GWAC Network

Han et al. 2020, in preparing

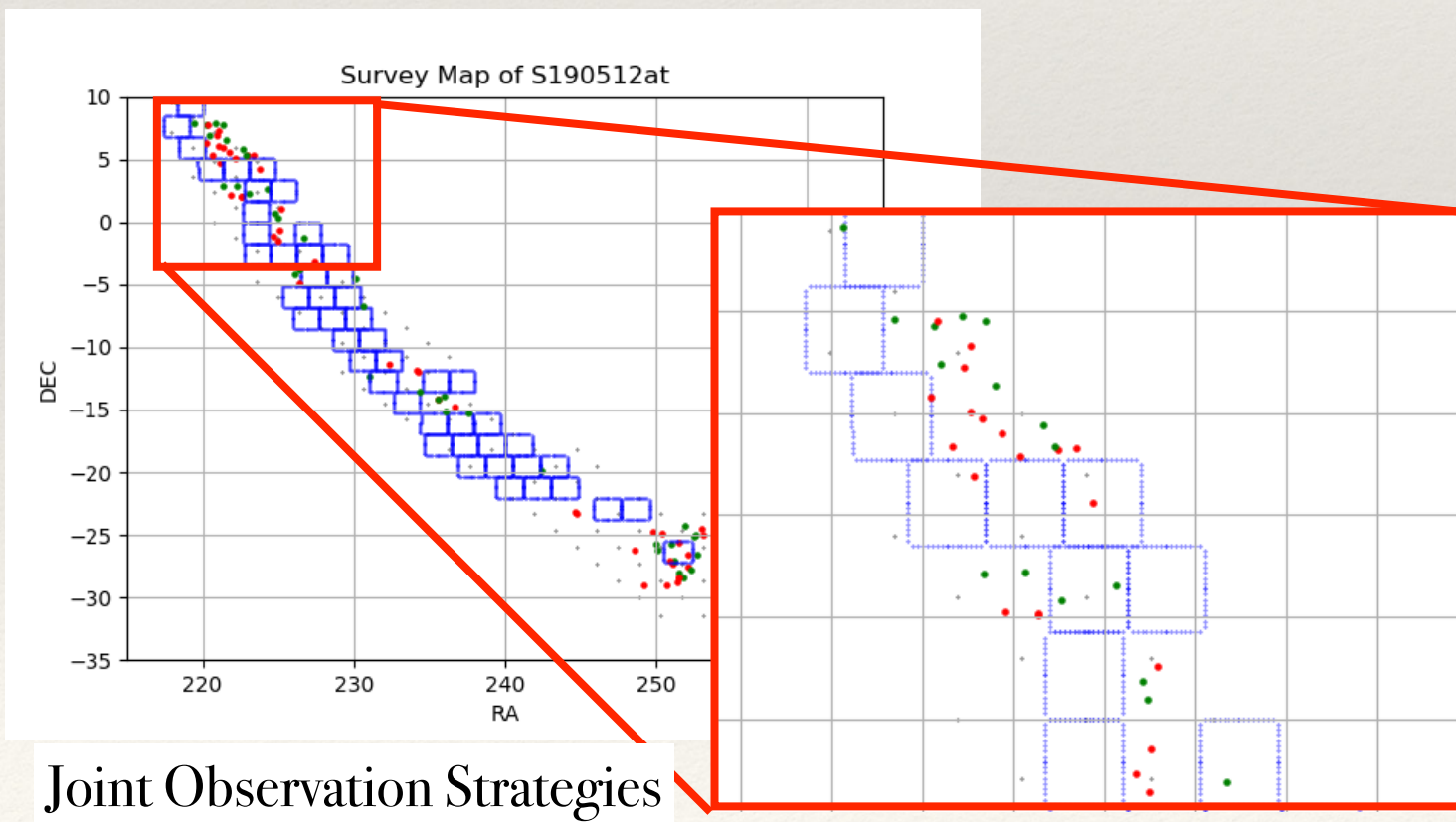
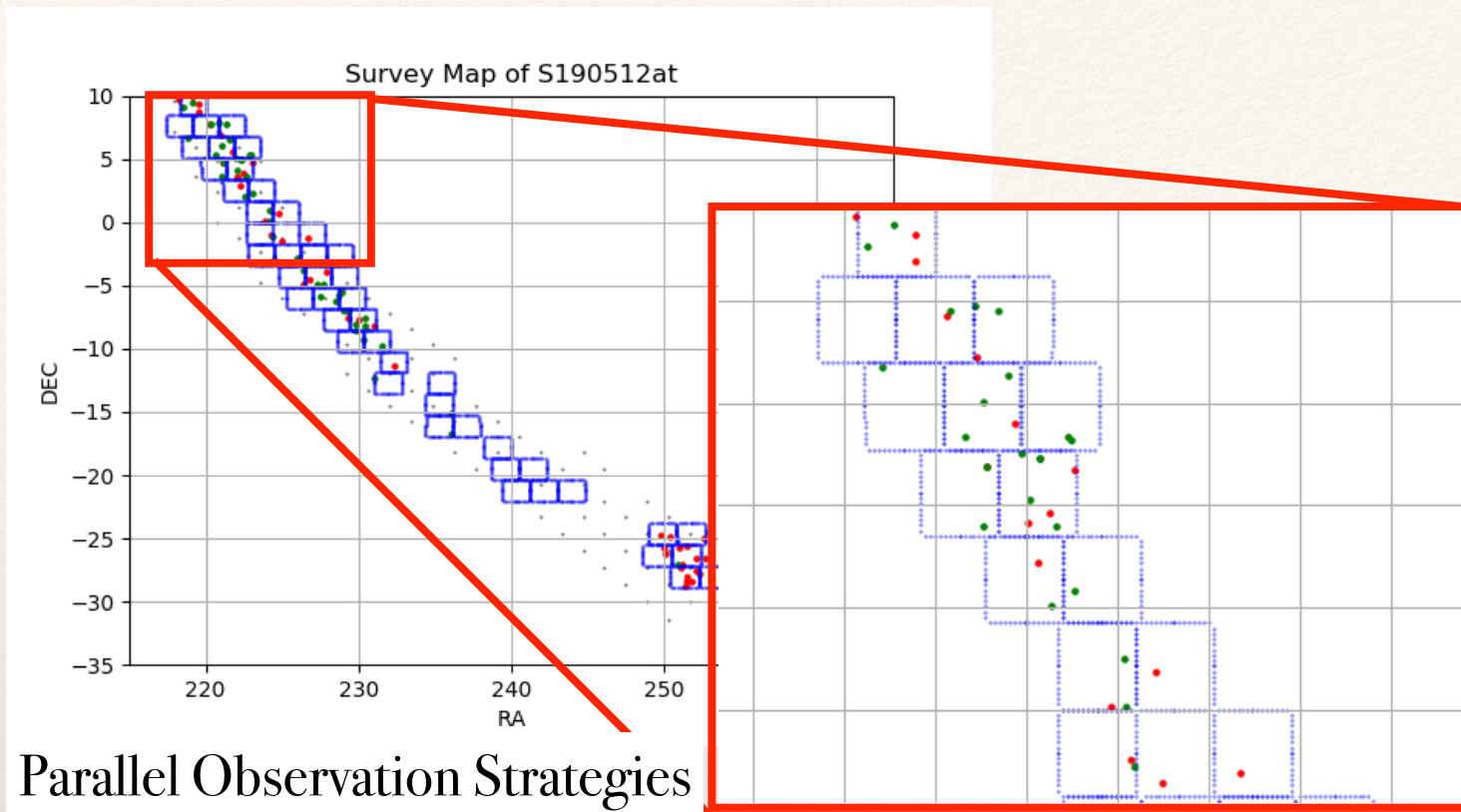
1. 实时动态处理和管理不同类型ToO警报
2. 实时动态制定和优化观测计划
3. 自主依据各望远镜特性和工作状态，实时动态组织和调度望远镜协同完成观测任务
4. 自动同步和归档观测数据



AOM系统的应用：F60A/B 和 30cm多望远镜协同观测策略



AOM系统提高了多望远镜的协同搜索效率



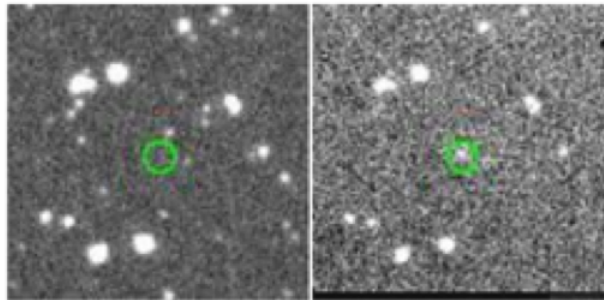
多望远镜**协同**观测的优势：

- 1.充分利用引力波的定位误差概率图以及不同观测设备的性能
- 2.在相同观测时间内，扩大了搜索范围
- 3.降低了可能发现对应体的延迟时间，从而提高发现概率

Han et al., 2020, in preparing

GWAC暂现源搜索：通过图像相减和星表交叉

Catalog crossmatch single images



下载详细

模板时间: 2018-12-18T21:46:16(U) 第7帧, 共11帧 起始帧 结束帧
切图名: G190414_C01129_0603.jpg

OT分类 OT坐标(赤经,赤纬): (13:00:13.390, 16:29:25.483) (195.05579, 16.490412)

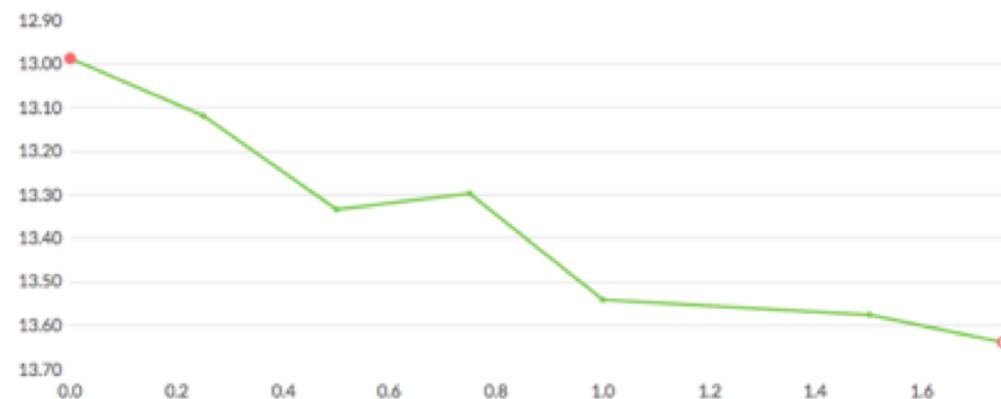
查看fits切图

多星表查询

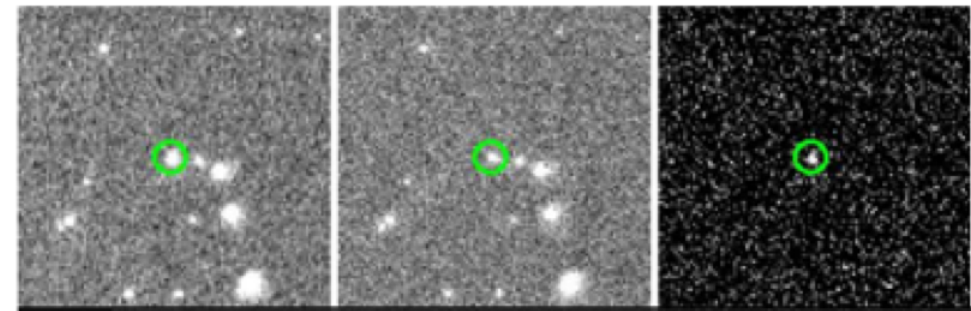
添加OT2的说明, 官方对该OT的定性描述。

提交说明

OT光变曲线 (X轴为时间, 单位/分钟, 开始于2019-04-14T14:29:51U, Y轴为星等值)



Differential image analysis stacking images



第11帧, 共23帧 切图名: G024_mon_objt_190330T15093311_00005.jpg

起始帧 结束帧

OT分类 OT坐标(赤经,赤纬): (11:33:31.344, 39:49:11.942) (173.3806, 39.819984)

多星表查询

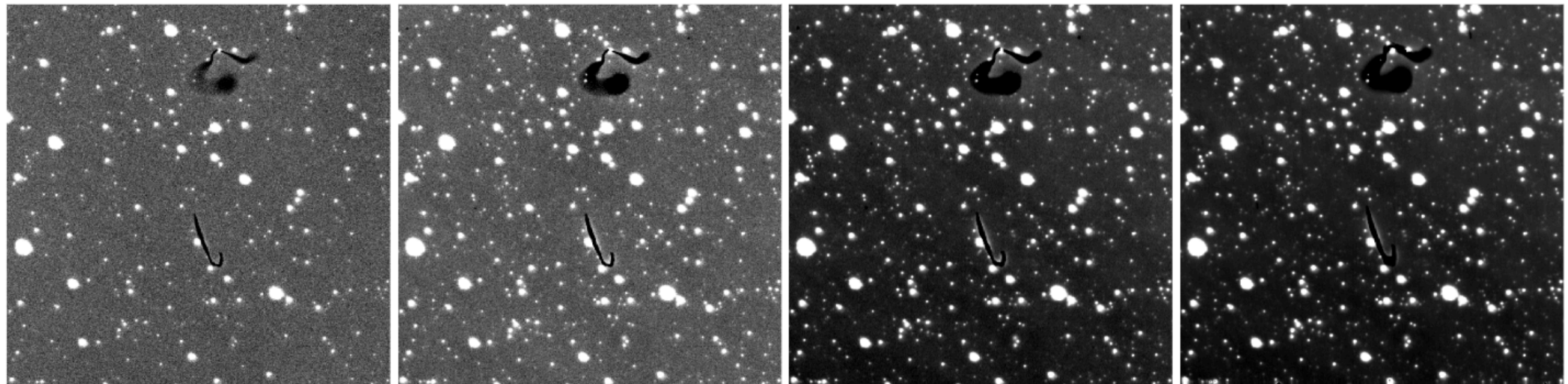
添加OT2的说明, 官方对该OT的定性描述。

提交说明

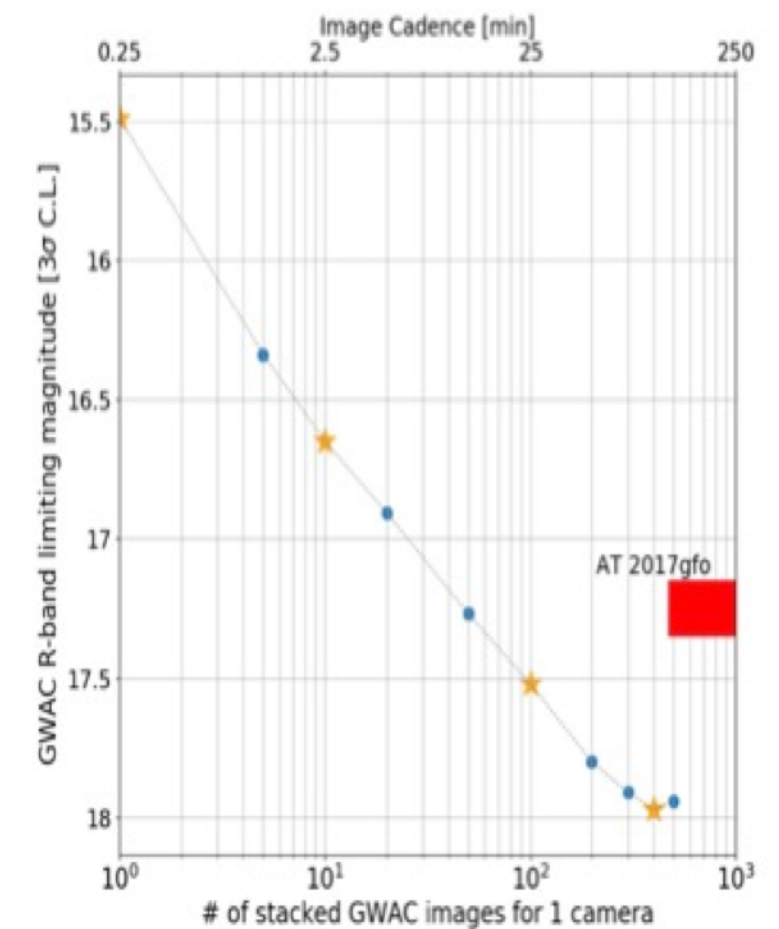
OT光变曲线 (X轴为时间, 单位/分钟, 开始于2019-03-30T15:07:03U, Y轴为星等值)



GWAC图像合并提高信噪比：搜索不同时标、不同亮度的暂现源



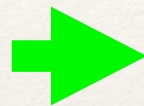
时间分辨率 (sec)	1	15	150	1500	3600
探测能力 (R)	~13	15.5	16.7	17.5	18.0



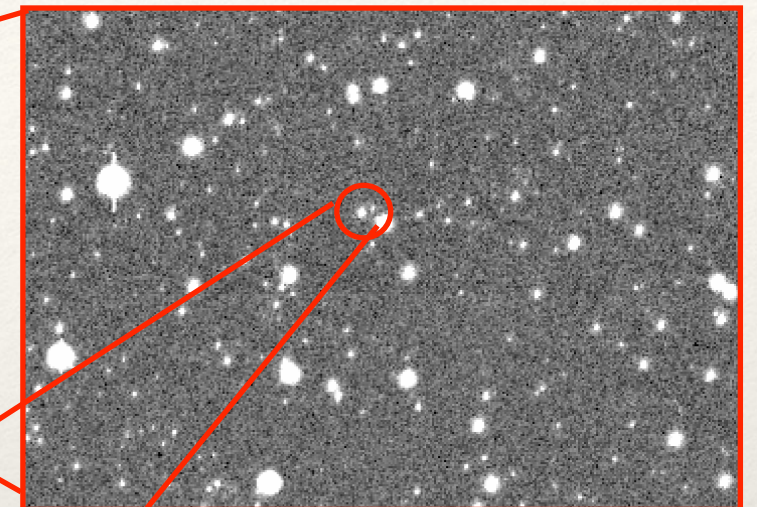
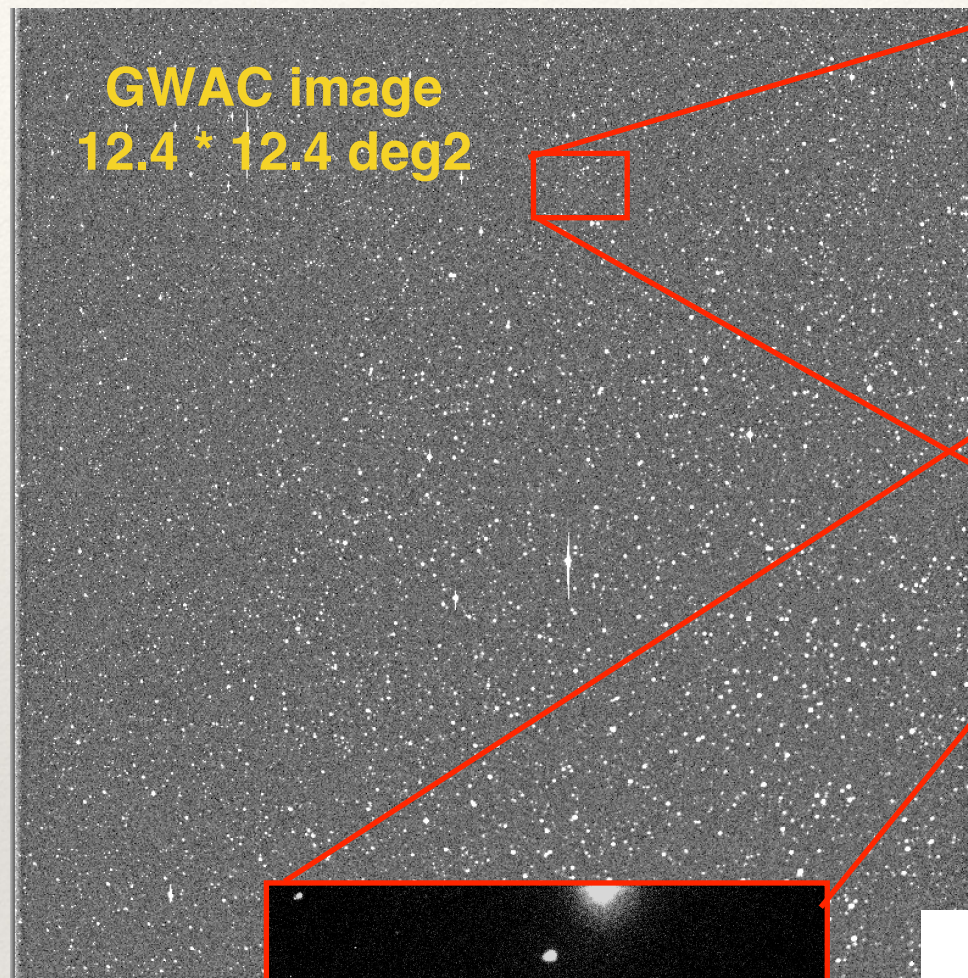
Turpin et al., 2020

从自主发现 (GWAC) 到自动后随和确认 (60cm)

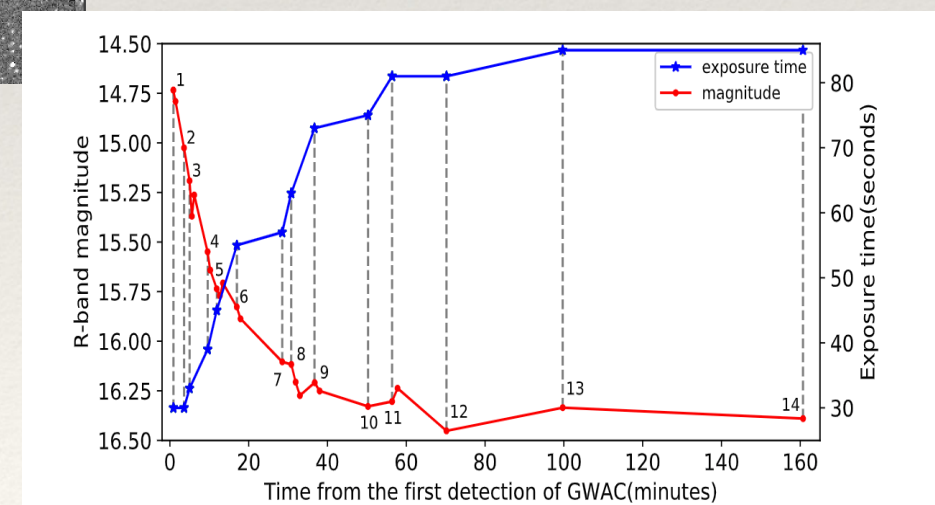
Xu, Xin et al., 2020



GWAC image
12.4 * 12.4 deg²

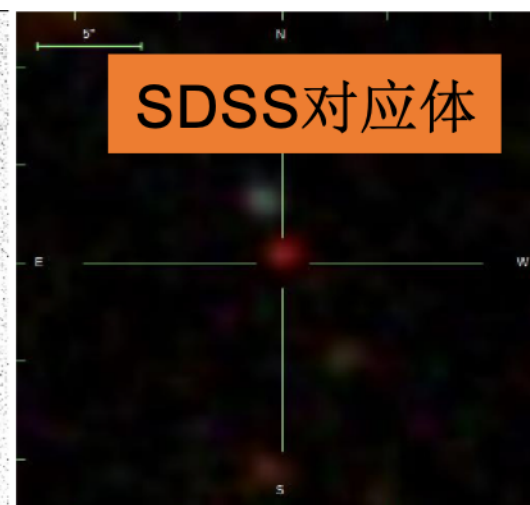
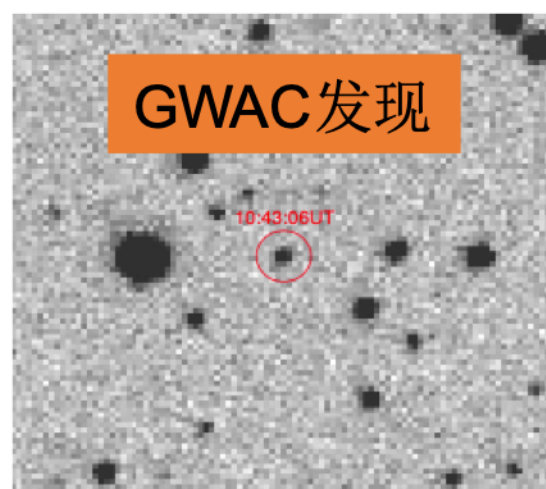


1. 后随时间延迟：1-2分钟
2. 自主动态调整观测策略

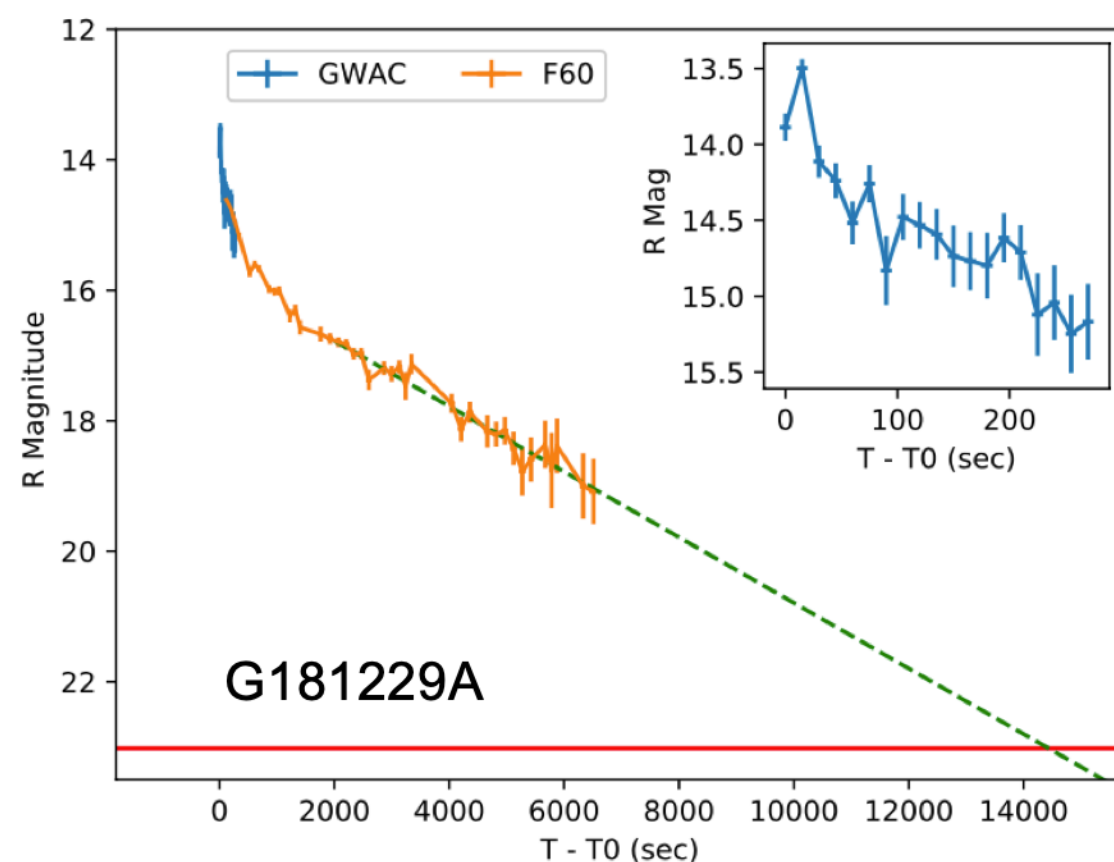


利用GWAC探测到了晚型恒星的超级耀发 (R波段9.4个星等)

Xin et al., 2020, submitted

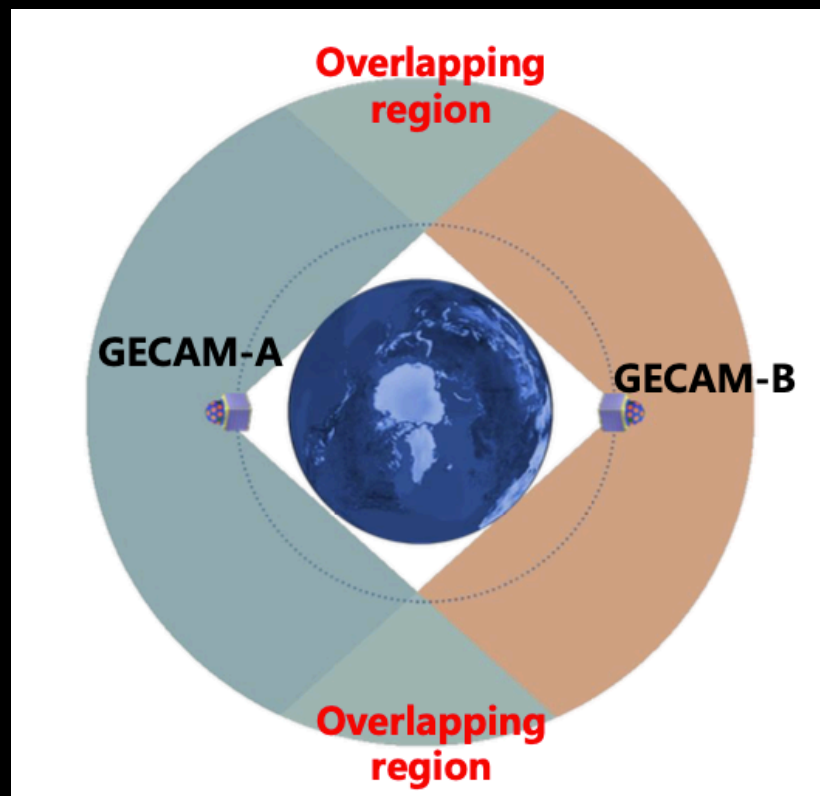


Casey Reed / NASA

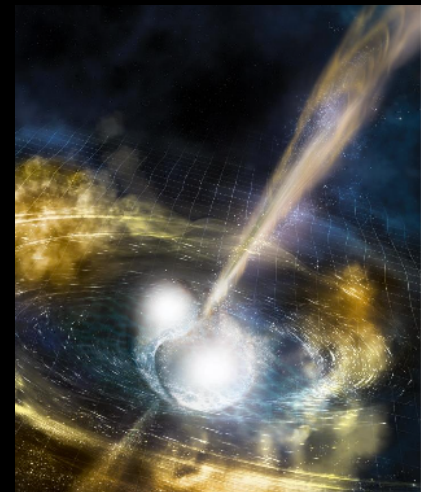


- M9 star
- 耀发幅度: $R \sim 9.4\text{mag}$
- 能量 $\sim 10^{35}\text{ erg}$
- 磁场强度 $\sim 4.6\text{kG}$
- 耀发填充因子 $\sim 30\%$ 表面积

天地联合策略：联合观测 + 数据分析



警报/信息
暂现源候选体



联合观测

- 情景1: 同步观测----瞬时光学辐射

- GECAM@100%全天观测
- GWAC的工作天区就是二者的共同覆盖天区
- 如果正好在该天区有事件发生，那么GWAC就可以提供不同时间分辨率的探测或极限星等。

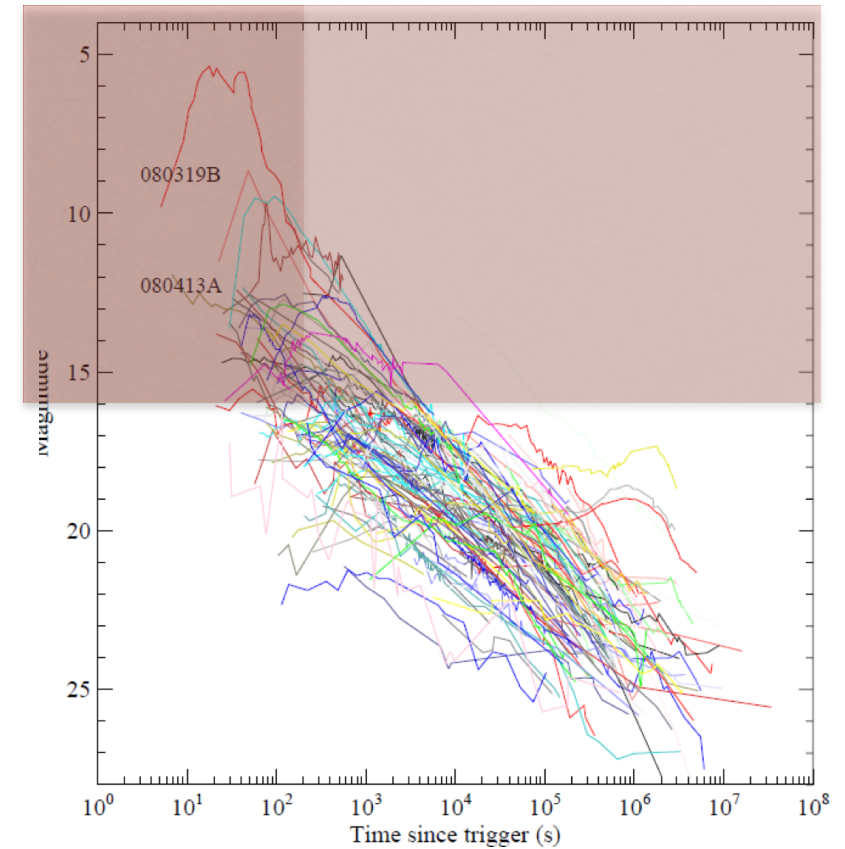
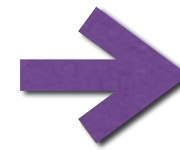
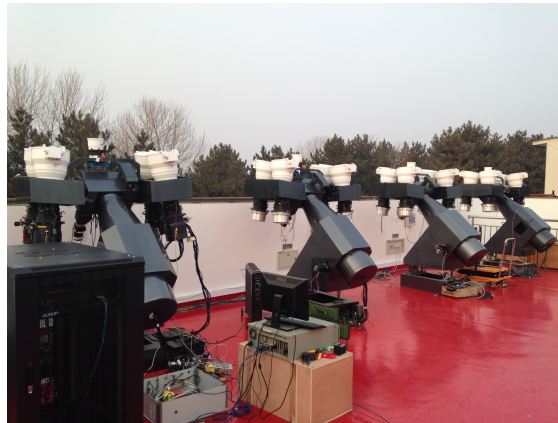
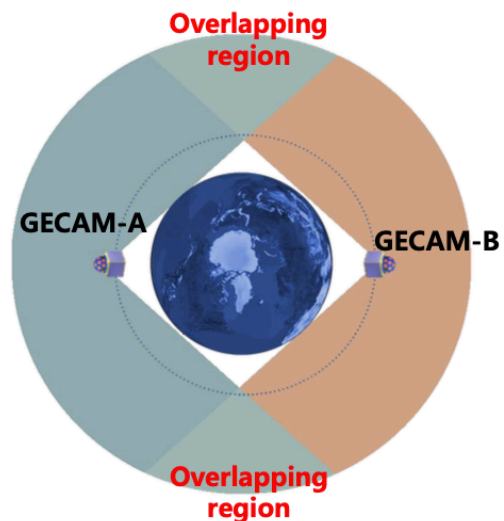
- 情景2: GWAC后随观测

- 如果GECAM触发的源不在GWAC观测天区，
- GWAC会进入ToO模式，转台会指向事件天区，一次性覆盖目标进行观测和光学对应体搜索。

- 情景3: F60/F30的后随观测

- F60视场：10角分/20角分；F30视场：1.8度
- 利用AOM调度系统进行快速后随和搜索

每年GWAC能同步/后随观测GECAM GRB数目估计



- 全天覆盖
- 全年：~500GRB
- 短暴：120个/年
- 爆发是全天随机

- GWAC~5000平方度（高银纬 $l > 20^\circ$ ）
- 可后随天区~10000平方度（ $ele > 30^\circ$ ）
- 晴天数：60%
- 工作时间：每天8小时（夜间，1/3天）
- 工作率：0.9
- 其他：0.7
- 每年同步观测数目是：~**7-10**个
- 每年快速后随（3分钟内）：~**20**个
- 几年下来就可以累积一个非常好的瞬时光学辐射样本

联合数据分析

- 利用**GWAC**历史数据进行交叉证认，反过来也是同样适用。

1.搜索**GECAM**的已确认暂现源的光学对应体

2.搜索和确认**GECAM**的未确认候选体，如低信噪比。

★ **GWAC**系统目前是通过**GCN**的方式来收取**Fermi/GW/Swift**警报。

★ 但是有一些信息却不是**public**的，我们是收不到了

L1) LAT Position Initial Notice (r-t) (Not available to the public, Fermi-Team use only)

contains an RA,Dec location for the burst/afterglow detected by LAT.

It starts the sequence of LAT Notices.

It is issued only once per burst.

It has the shortest integration of source and background photons.

The position comes from the LAT flight software
scanning the time and spatial domains.

The position uncertainty is 60-120 arcmin (it depends on the number of photons detected and their energies).

谢 谢